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Small Ruminant Research 26 (1997) 253–260

Small Ruminant Research

# Daily variations in somatic cell count, composition, and production of Alpine goat milk

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Accepted 30 November 1996

**Abstract**

Twelve milking Alpine does were randomly selected from the Langston University herd to determine the daily variations of milk somatic cell counts (SCC), composition and production. Composite milk samples were collected daily at evening milking from mid-March (2–3 weeks in lactation) to mid-August (drying-off) in 1995. Milk samples were analyzed for SCC using a Fossomatic cell counter and for chemical composition using a Dairylab II milk analyzer. Both instruments were calibrated with goat milk standards. Concentrations of all milk composition variables (fat, protein, solids-non-fat and total solids), with the exception of lactose, were high ($2.91 \pm 0.16\%$, $3.27 \pm 0.10\%$, $8.30 \pm 0.11\%$ and $11.20 \pm 0.23\%$, respectively) in the first month after parturition, declined slightly and then remained constant until drying-off. Daily milk production increased steadily for the first 4 weeks following parturition and then decreased gradually. SCC in milk were high ($887 \pm 400 \times 10^3$ ml$^{-1}$) during the first 2 weeks of lactation. The lowest SCC were found in milk during the second month after parturition and then the SCC value increased as lactation advanced. Marked daily variations of SCC in goat milk were observed. These observations indicate that consecutive monthly SCC data collected from the once-a-month sampling plan of the Dairy Herd Improvement Association testing program must be used if the SCC is to be a direct estimator of mastitic conditions in Alpine goats. © 1997 Elsevier Science B.V.

*Keywords:* Somatic cell count; Goat milk; Daily variation

## 1. Introduction

Goat milk research over the last decade has demonstrated that major milk components (e.g. fat and protein), somatic cell counts (SCC) and daily milk yield vary throughout lactation depending on numerous factors such as morning versus evening milkings, stage of lactation, breed (Calderon et al., 1984; Park and Humphrey, 1986; Kala and Prakash, 1990; Voutsinas et al., 1990; Park, 1991; Simos et al., 1991; Zeng and Escobar, 1995, 1996). However, there is a lack of data on daily variation of composition and especially SCC in goat milk.

Currently, there are approximately 13 000 dairy goats enrolled in the Dairy Herd Improvement Association (DHIA) testing program in the United States (National DHIA, personal communication). Proper testing plans and sampling procedures are critical for obtaining accurate test results of milk samples. This is particularly true for the SCC, which is used as an estimator of mammary inflammation.

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*PII* S0921-4488(96)01002-4

To document the performance of herds and individual goats for traits such as fat, protein, SCC and milk production, goat milk samples are collected monthly in the DHIA testing program. Objectives of the current study were to investigate the daily variations of SCC, composition and yield of goat milk and to determine correlations between tested variables.

## 2. Materials and methods

### 2.1. Experimental animals

Twelve healthy milking does in their first lactation were randomly selected from the Alpine herd in the E (Kika) de la Garza institute for Goat Research at Langston University, OK. The does were fed with a high grain and low fiber ration (15.2% crude protein) and kept on dry lot with alfalfa hay between morning and evening milkings with the remaining herd. All does were kept in a lactation barn during the night. The experimental does kidded between late February and early March and were dried off in mid-August 1995. Automatic milking machines (BOU-MATIC, DEC international, Madison, WI) were used to milk the does daily at 4:00 and 16:00. The milk production of each doe was recorded daily by a computerized system (Westfalia Systemat, Elk Grove Village, IL).

### 2.2. Sample collection

Sample collection commenced when does were one to two weeks in lactation. Milk samples were collected daily from evening milking using Waikato goat sampling meters (Waikato Milkmeter, InterAg, Hamilton, New Zealand) attached to the milking machines. The sample was placed in a milk sample vial (Capital Vials, Fultonville, NY) and preserved using Microtabs (Control Systems, Inc., San Ramon, CA) for SCC determination and chemical composition analysis.

### 2.3. Sample analyses

Goat milk was analyzed within 24 h of collection at the Dairy Herd Improvement Association (DHIA) Laboratory for Goats at Langston university. SCC were determined using a Fossomatic-300 cell counter (Foss Electric, Hillerod, Denmark). Milk components (fat, protein, lactose, solids-non-fat (SNF) and total solids (TS)) were analyzed using a Dairylab II milk analyzer (Multispec Ltd., Wheldrake, York, England). Both instruments were calibrated bi-weekly with goat milk standards, instead of the conventional cow milk standards, prepared by Dairy Quality Control, Inc. (DQCI), St. Paul, MN, to maintain accurate instrument performances.

### 2.4. Statistical analysis

Data were analyzed using the general linear model (GLM) procedure of Statistical Analysis System (SAS, 1989) to evaluate changes over time. Statistical analysis showed that SCC in goat milk were not normally distributed. Therefore, the actual SCC were transformed to logarithm forms for further statistical analyses. When the GLM indicated significant differences, mean separation was performed according to the Ryan-Einot-Gabriel-Welsch multiple $F$-test. Pearson correlation coefficients among different variables of goat milk were calculated using the CORR procedure.

## 3. Results and discussion

The overall means, standard deviations and ranges of all tested variables in goat milk are summarized in Table 1. Milk from this Alpine herd had lower fat

Table 1
Overall means of major constituents (%), somatic cell count (ln) and daily yield (kg/doe) in Alpine goat milk ($n = 1848$)

| Variable | Mean | SD[a] | Range |
|---|---|---|---|
| Fat | 2.46 | 0.76 | 1.00–10.16 |
| Protein | 2.79 | 0.66 | 0.82–8.52 |
| Lactose | 4.17 | 0.44 | 1.50–6.76 |
| SNF[b] | 7.50 | 0.73 | 5.10–10.60 |
| TS[c] | 9.95 | 1.20 | 7.92–20.76 |
| SCC[d] (log) | 5.48 | 1.55 | 3.00–6.99 |
| SCC ($\times 10^3$ ml$^{-1}$) | 616 | 387 | 0–3000 |
| Daily yield | 1.98 | 0.71 | 0.41–5.45 |

[a] Standard deviation.
[b] Solids-non-fat.
[c] Total solids.
[d] Somatic cell count.

Table 2
Mean separations of major constituents (%) and daily yield (kg/doe) of Alpine goat milk at different stages of lactation

| Month | $n^a$ | Fat | Protein | Lactose | SNF | TS | Yield |
|---|---|---|---|---|---|---|---|
| March | 204 | $2.91^b$ | $3.27^b$ | $4.44^b$ | $8.30^b$ | $11.20^b$ | $2.28^b$ |
| April | 360 | $2.26^c$ | $2.85^c$ | $4.33^b$ | $7.76^c$ | $10.01^c$ | $2.22^b$ |
| May | 372 | $2.26^c$ | $2.68^c$ | $4.08^c$ | $7.33^d$ | $9.87^c$ | $2.13^b$ |
| June | 360 | $2.53^c$ | $2.69^c$ | $4.13^c$ | $7.32^d$ | $9.74^c$ | $1.98^{b,c}$ |
| July | 372 | $2.46^c$ | $2.73^c$ | $4.07^c$ | $7.28^d$ | $9.72^c$ | $1.64^{b,c}$ |
| August | 180 | $2.45^c$ | $2.64^c$ | $4.08^c$ | $7.27^d$ | $9.59^c$ | $1.42^c$ |

[a] Number of observations.
[b, c, d] Means in the same column followed by same letters are not significantly different according to the Ryan-Einot-Gabriel-Welsch multiple $F$-test ($P > 0.05$).

and protein contents than the national averages reported by the American Dairy Goat Association (Wierschem, 1993). This was probably because of the high grain and low fiber ration fed to the does. Mean SCC for the whole lactation was $6.16 \times 10^5$ ml$^{-1}$. Overall, 17% milk samples contained more than $1.0 \times 10^6$ SCC ml$^{-1}$, the legal limit for Grade A goat milk in the United States. This figure was considerably lower than previously observed in the same herd. When milk samples were collected only monthly, 51% of them exceeded the limit (Zeng and Escobar, 1995). This difference could be attributed partially to the calibration of the Fossomatic-300 cell counter with goat milk SCC standards used in this study. The automatic cell counter overestimates SCC in goat milk by 27% when calibrated with cow milk rather than goat milk standards (Zeng, 1996). Among the twelve goats studied in this experiment, two had consistently high SCC ($> 1.0 \times 10^6$ ml$^{-1}$) throughout the experimental period (73% and 77% of their daily samples, respectively). However, no clinical mastitis was observed in either goat.

Table 2 shows the mean separations of tested variables in goat milk at different stages (months) of lactation. Milk samples of the first month after parturition had higher fat, protein, SNF and TS than those of the later lactation stages ($P < 0.05$). No differences were detected between April and August ($P > 0.05$). Lactose content during the first two months was higher than that for the remainder of the lactation ($P < 0.05$). The daily milk production of does in first three months of lactation was higher than that of does in August ($P < 0.05$).

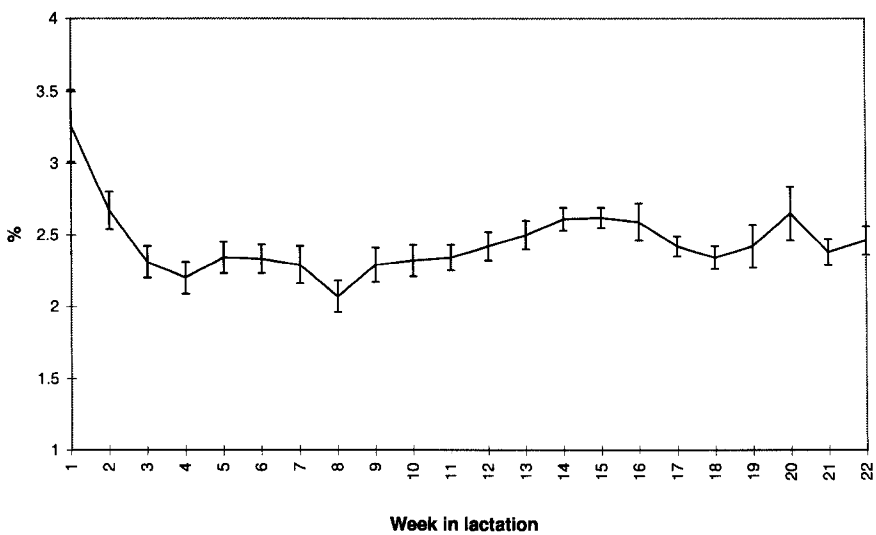


Fig. 1. Variations of fat content (%) in Alpine goat milk during lactation (weekly means of daily samples).

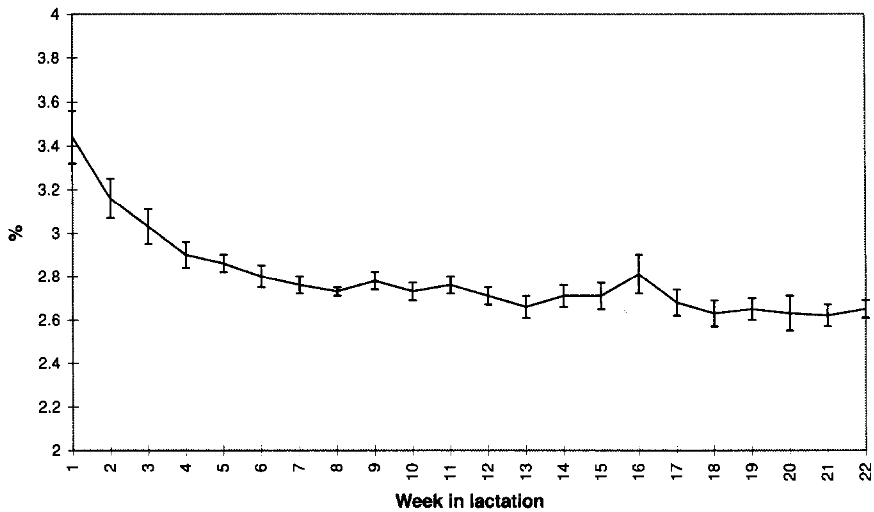


Fig. 2. Variations of protein content (%) in Alpine goat milk during lactation (weekly means of daily samples).

The variations of milk composition are shown in Figs. 1–4 with weekly means of daily milk samples during lactation. When daily data of milk composition in samples of 12 goats were pooled on a weekly basis, all components except lactose decreased in concentration as lactation progressed. No marked variations of chemical composition in daily milk samples were observed. As Fig. 5 indicates, experimental does had typically low milk yields in their first lactation, ranging from 2.41 to 1.38 kg/doe per day. Goats reached their peak milk production (2.41 ± 0.20 kg/doe per day) in approximately 4 weeks

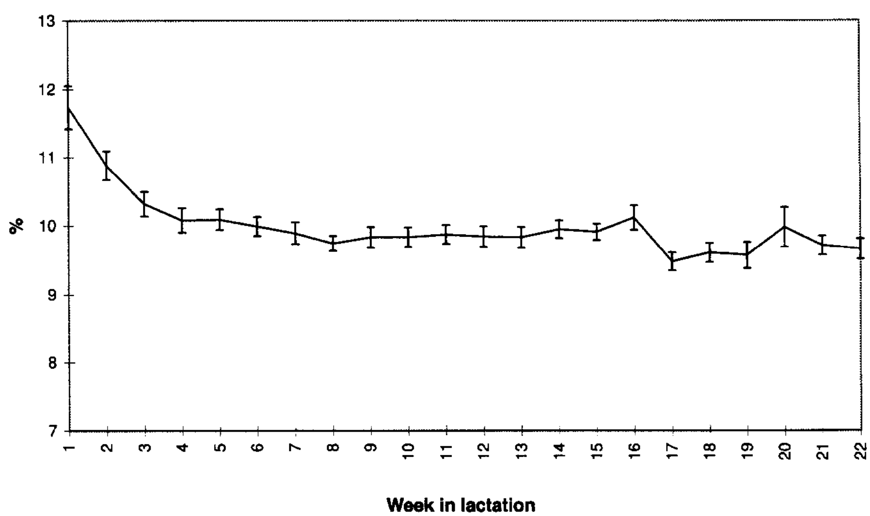


Fig. 3. Variations of total solids (%) in Alpine goat milk during lactation (weekly means of daily samples).

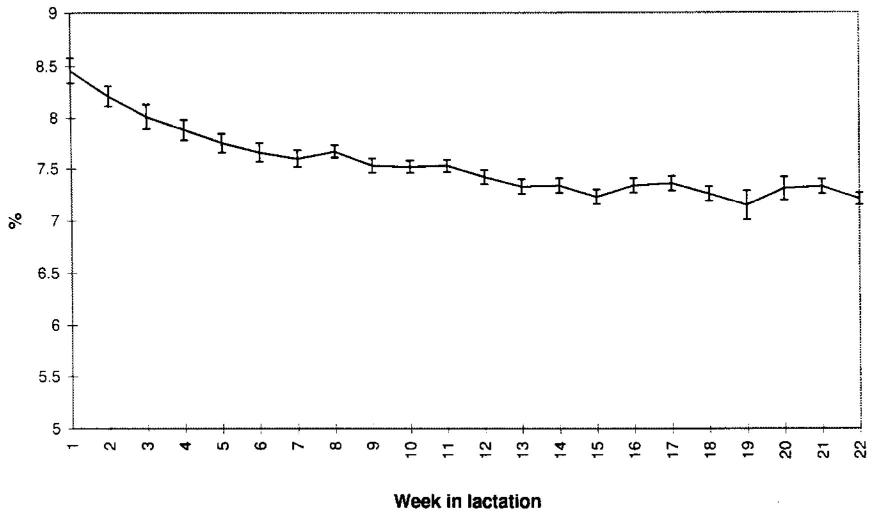


Fig. 4. Variations of solids-non-fat (%) in Alpine goat milk during lactation (weekly means of daily samples).

after parturition. A gradual decline of milk production was observed as lactation advanced towards drying-off. Previous publications have observed variations in goat milk composition at different stages of lactation when different sampling regimens were used (Calderon et al., 1984; Brendehaug and Abrahamsen, 1986; Kala and Prakash, 1990; Voutsinas et al., 1990; Simos et al., 1991).

The weekly means of SCC in daily samples are shown in Fig. 6. The SCC of milking does started at over $1.0 \times 10^6$ ml$^{-1}$ in the first week after parturition. The stresses of kidding and post-kidding recov-

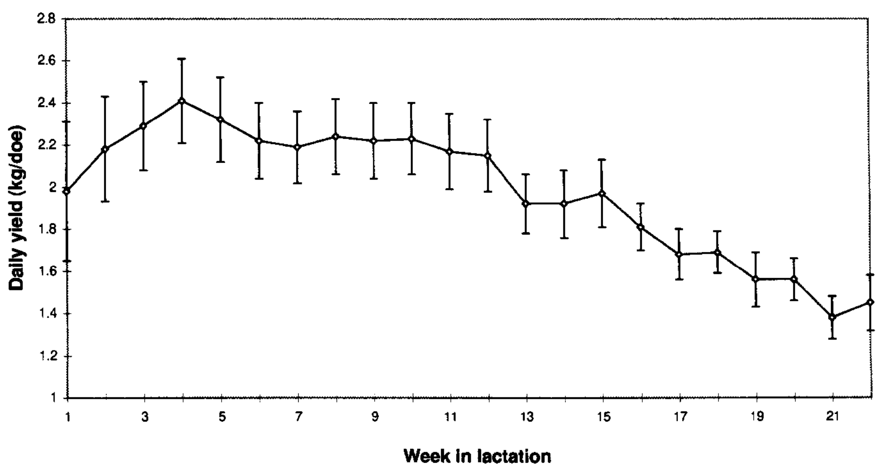


Fig. 5. Milk production during lactation of Alpine goats (weekly means of daily production ± standard error).

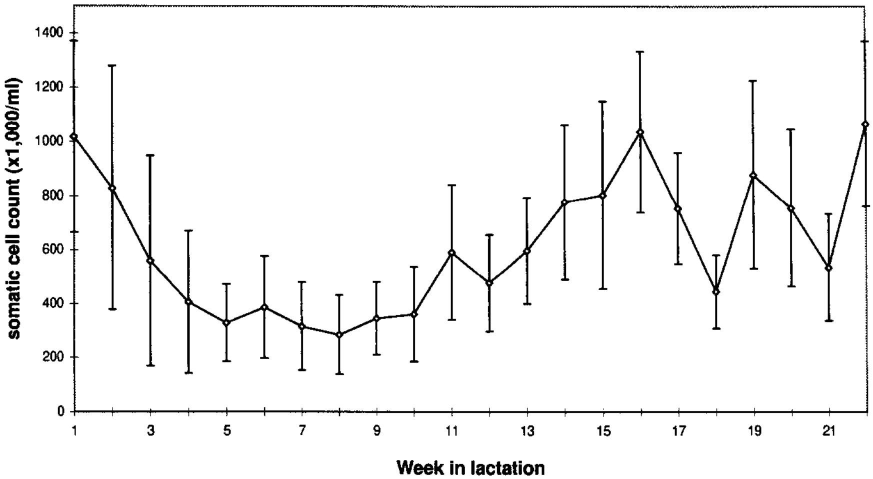


Fig. 6. Variation of somatic cell counts (SCC) in milk during lactation of Alpine goats (weekly means of daily samples ± standard error).

ery could contribute to the high SCC. A dramatic decrease of SCC was observed over the first 5 weeks. The lowest SCC were found in the daily milk samples collected from 1 to 3 months in lactation. Then SCC increased with marked fluctuations in late lactation. In contrast, Zeng and Escobar (1995) reported that SCC of Alpine goat milk increased steadily from early to late lactation when samples were collected monthly.

Daily variations in mean SCC of milk from 12 does are illustrated in Fig. 7. Mean daily SCC fluctuated markedly (coefficient of variation = $192 \times 10^3$ $ml^{-1}$), particularly in late lactation. Fig. 8 displays the daily variations of SCC in milk of an individual doe with a coefficient of variation of $189 \times 10^3$ $ml^{-1}$. This particular doe had an SCC below $400 \times 103$ $ml^{-1}$ in 91% of its milk samples and did not display any mastitis symptoms during the experi-

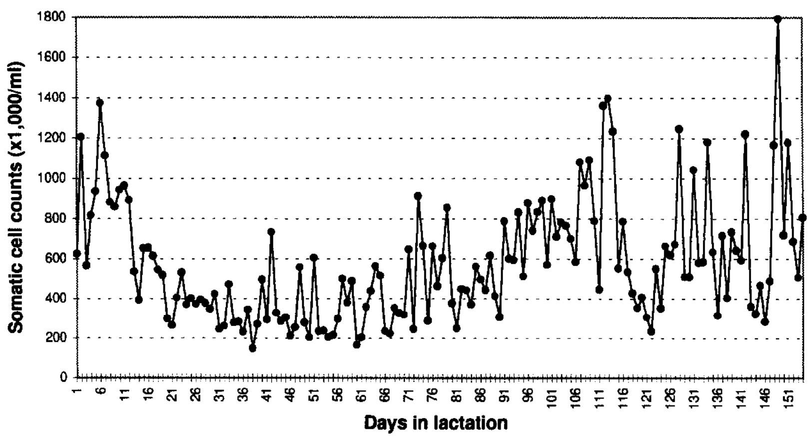


Fig. 7. Daily variation of somatic cell counts (SCC) in milk during lactation of Alpine goats (means of 12 samples).

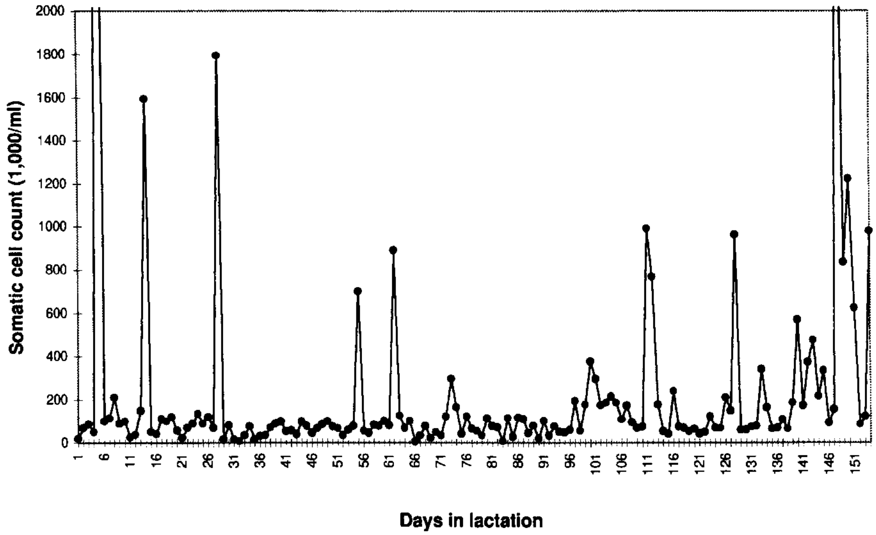


Fig. 8. Daily variation of somatic cell counts (SCC) in milk during lactation of an individual Alpine goat.

ment. However, during the course of this study, seven samples (9%) had SCC over $1.0 \times 10^6$ ml$^{-1}$ (two were above $2.0 \times 10^6$ ml$^{-1}$) while their previous or next test-day samples had SCC below the limit of $1.0 \times 10^6$ ml$^{-1}$ (Fig. 8). Therefore, a single test-day measurement of SCC will not be adequate to efficiently estimate the mastitis conditions of individual goats. When SCC data from the monthly DHIA testing program are used for mastitis control in dairy goats, the records of consecutive monthly reports, along with health conditions and milk production, should be used in making antibiotic treatment or culling decisions.

The correlation coefficients between tested variables of pooled data ($n = 1848$) are displayed in Table 3. Positive correlations were found between fat, protein or lactose and SNF or TS ($P < 0.001$). Positive relationships also existed between SCC and fat, protein, SNF or TS ($P < 0.001$) although the values were low. Daily milk yield had negative correlations with SCC and fat content ($P < 0.001$). No relationships were observed between TS or protein and milk production ($P > 0.05$). The different sampling regimens and the stages of lactation dramatically affected the correlation coefficients between SCC and fat or protein content in goat milk. The daily samples and the large number of samples during a complete lactation applied in this study

Table 3
Correlation coefficients between fat, protein, lactose, solids-non-fat (SNF), total solids (TS), somatic cell count (SCC) and daily yield of Alpine goat milk ($n = 1848$)

| | Protein | Lactose | SNF | TS | SCC | Yield |
|---|---|---|---|---|---|---|
| Fat | 0.24 | 0.14 | 0.30 | 0.82 | 0.24 | −0.15 |
| Protein | | 0.25 | 0.51 | 0.47 | 0.17 | 0.04[a] |
| Lactose | | | 0.82 | 0.59 | −0.04[a] | 0.17 |
| SNF | | | | 0.78 | 0.13 | 0.14 |
| TS | | | | | 0.24 | −0.01[a] |
| SCC | | | | | | −0.09 |

All correlations were significant $p < 0.001$ except [a]; $p > 0.05$

resulted in correlation coefficients of 0.24 and 0.17, respectively.

## 4. Conclusion

The results of the current investigation indicate that the concentration of milk components changed depending on the stages of lactation; however, daily variations were not significant. Daily milk production increased after parturition (4 to 5 weeks in lactation) and then decreased gradually as lactation advanced. SCC in Alpine goat milk were found to be high in early (2 to 3 weeks) and late (4 to 5 months) lactation with marked daily variations. Therefore, a once-a-month testing plan is inappropriate if the SCC data are to be used as an indicator of intramammary inflammation in Alpine goats. SCC records of consecutive months must be examined and a culturing test may be performed before a milking doe is treated or culled based on SCC in milk. A threshold value of SCC in milk for subclinical mastitis in dairy goats needs to be established to classify infected and uninfected goats. Bacteriological examinations (particularly mastitis-related pathogens) of goat milk will help the establishment of the SCC threshold.

## Acknowledgements

This field study was funded by the Research and Extension programs at the E (Kika) de la Garza Institute for Goat Research, Langston University. The authors gratefully thank Mr E. Sullivan for his laboratory assistance. Appreciation is also given to Mr G. Detweiler and the farm crew of the Institute for assistance with animal care and sample collection.

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